(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 992 314 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.04.2000 Bulletin 2000/15

(51) Int Cl.[7]: **B23K 20/12**

(21) Application number: **99307638.9**

(22) Date of filing: **28.09.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **29.09.1998 JP 27461898**

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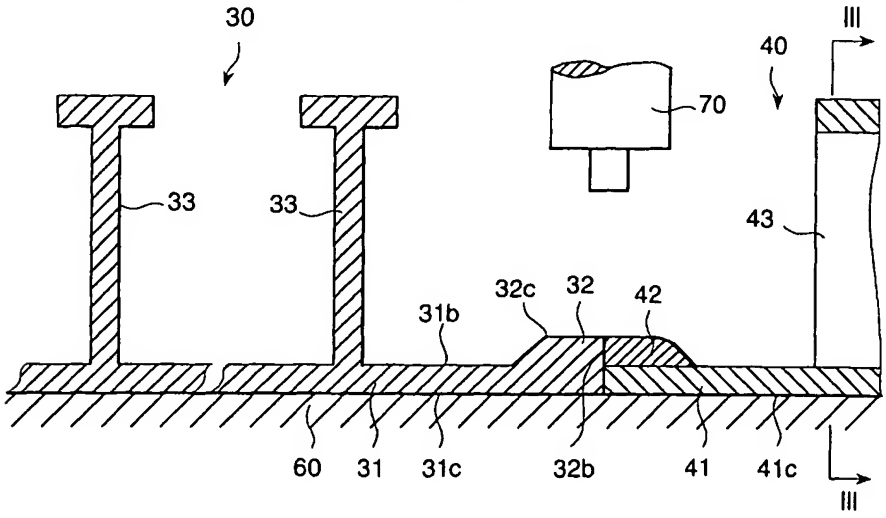
(54) **Friction stir welding and welded structures produced thereby**

(57) In a welded structure, e.g. a side structure of a railway car body, a raised portion 32 is provided on an upper face of an end portion of a plate 31 of one frame member 30. An end portion of a plate 41 of another frame member 40 is abutted to the plate 31, so that there is a height difference at their welding surfaces. The frame members 30 and 40 are aluminium alloy extruded frame members. Their extrusion directions are orthogonal. Padding welding is carried on an upper face of the plate 41 to raise it at least partially. From the upper side a rotary tool is inserted to carry out friction stir welding. The padding welding portions serve the same function of the raised portion 32 and good quality welding can be carried out.

FIG. 1



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Description

Background of the Invention:

[0001] The present invention relates to a friction stir welding method used, for example, for aluminium alloy material frame members etc., and in particularly to a friction stir welding method used, for example, in a case where the height position of portions subjected to the welding of two abutted frame members made of aluminium alloy materials differs. The invention also relates to structures produced by means of friction stir welding.

[0002] As shown in EP-A-797043, friction stir welding is a method in which by rotating a round rod (called a rotary tool) inserted into a welding portion of two abutted members and moving the rotary tool along a welding line, the welding portion of the two members is thermoplastically heated and is plastically fluidized and thereby welded.

[0003] The rotary tool comprises a small diameter portion for inserting to the welding portion and a large diameter portion which is positioned at an end of the small diameter portion. The small and large diameter portions of the rotary tool are positioned on the same axis and are rotated together. Friction stir welding is applied to an abutting portion and an overlapping portion of the two frame members which are made of aluminum alloy materials, for example.

[0004] Further, the welding portion of one or both frame members to be subjected to the welding may have a raised portion or upward projection which protrudes towards the large diameter portion of the rotary tool. This raised portion of the frame member is provided integrally at an end of a cross member of a hollow extruded frame member. The raised portion provides material for burying a gap which is formed between the two frame members. When a face of frame member forms an outer face of a product, for example, an outer side of a car body of a railway vehicle, any residue of the raised portion of the frame member is cut off after the welding.

[0005] When the raised portion is provided on an extruded frame member, the raised portion can extend in the extrusion direction. However, the raised portion of the frame member cannot be provided at an end portion of the extruded member; in other words, the raised portion of the frame member cannot be provided perpendicular to the extrusion direction.

[0006] As a result, when two extruded frame members are arranged orthogonally each other and end portions of the extruded frame members are to be welded by the friction stir welding method, at an end portion of one extruded frame member the integral raised portion is present, but on the other extruded frame member no raised portion is present.

[0007] Accordingly, it is considered that satisfactory welding of the two extruded frame members cannot be carried out, because one of the frame members does not have the raised portion at the welding zone.

[0008] The above described case is one example in which the height positions of the surfaces at the width direction of the two extruded frame members of the welding portion differ each other; in other words the height position of the surface at the width direction of the one frame member differs from the height position of the surface at the width direction of the other frame member or the height position of the surface at the width direction of the one frame member is higher or lower than the height position of the surface at the width direction of the other frame member.

Summary of the Invention:

[0009] An object of the present invention is to provide to a friction stir welding wherein good welding can be obtained even when the height positions of the surfaces of the two members of the welding portion differ.

[0010] According to the invention in one aspect when the height positions of the surfaces of the two members of the welding portion differ, padding welding is carried out on the surface of the member at the low side and then friction stir welding is carried out on the welding portion of the two members.

[0011] Further, the expression "the height positions of the surfaces of the two members of the welding portion differ" indicates that the surface side, for example, of the members has an upper portion and a lower portion, with respect to the rotary tool which is a reference for determination of position; it means that the distance from the rotary tool to the surface of the welding portion differs, for example. The expression "the member being the low side" refers to the member which has the larger distance from the rotary tool.

[0012] The padding welding, or pad welding, is carried out along at least part or parts of the friction stir weld line in order to raise the surface of the low side member towards the level of the surface of the high side member, thereby at least partially to remove the height difference where the pad or pads are formed. The pad welding may be continuous or intermittent along the friction stir welding line.

Brief Description of Drawings

[0013] Embodiments of the invention will now be described by way of example, with reference to the drawings.

Fig. 1 is a longitudinal cross-sectional view of a welding portion of two frame members of a friction stir welding of one embodiment according to the present invention and is a cross-sectional view on line I-I of Fig. 6;

Fig. 2 is a perspective view of a part of a welding portion of the two frame members of Fig. 1;

Fig. 3 is a cross-sectional view on line III-III in Fig. 1 of a rib of the frame member of Fig. 1;

Fig. 4 is a longitudinal cross-sectional view on line IV-IV in Fig. 6 of a welding portion of another two frame members welded in this embodiment according to the present invention;

Fig. 5 shows the condition after the friction stir welding has carried out on the two frame members of Fig. 4;

Fig. 6 is a side view of a car body of a railway vehicle on which the friction stir welding is carried out according to the present invention;

Fig. 7 is a side view of another car body of another railway vehicle on which friction stir welding is carried out according to the present invention;

Fig. 8 is a cross-sectional view on line VIII-VIII of Fig. 7 of the two frame members of Fig. 7; and

Fig. 9 is a cross-sectional view showing a car body of a further railway vehicle on which the friction stir welding is carried out according to the present invention and corresponds to the embodiment shown in Fig. 8.

Description of the Embodiments:

[0014] A friction stir welding method of one embodiment of the present invention will be described with its application to a car body of a railway vehicle, referring to Figs. 1 to 6.

[0015] In Fig. 6, a portion of the side structure 20 of the body of the railway vehicle is shown constituted by combining plural aluminium alloy extruded frame members 30, 40 and 50. The extrusion direction of the frame members 30, which are arranged between an entry and exit port or door region 21 and a window 25 and between adjacent windows 25, is perpendicular to the longitudinal direction of the body in Fig. 6. The extrusion direction of the extruded frame members 40 below the window 25 is in the longitudinal direction in Fig. 6. In other words, the respective extrusion directions of the extruded frame members 30 and extruded frame members 40 are orthogonal.

[0016] The extrusion direction of the extruded frame member 50 arranged above the port 21 is in the longitudinal direction of the body in Fig. 6. Reference numeral 28 indicates a bottom frame of the car body. All these members are welded together by friction stir welding and by conventional MIG welding.

[0017] Referring to Figs. 4 and 5, the friction stir welding of two of the extruded frame members 30 to each other, whose extrusion directions are the same, will be explained. The friction stir welding of the adjacent extruded frame members 40 to each other is carried out similarly.

[0018] The extruded frame member 30 (and also each of the frame members 40 and 50) has a flat plate 31 at the exterior of the car body and ribs 33 perpendicular to the plate 31 at the inside of the car body. The ribs 33 extend in the extrusion direction of the extruded frame member 30.

[0019] At the end portion, where the frame members 30 abut each other, in the width direction (the direction orthogonal to the extrusion direction) the extruded frame member 30 has a thickening constituted by an upward projection or raised portion 32 at the car body inside. The protrusion height of the raised portion 32 of the frame member 30 is shown as h. The end face 32b of the plate 31 and the raised portion 32 is substantially orthogonal to the outer face of the plate 31 of the frame member 30 and to the top face 32c of the raised portion 32. Accordingly, when the two extruded frame members 30 are abutted, the end faces 32b of the end portions of the plates 31 of the two frame members 30 contact each other. However, this is an ideal case. The abutted portion may be said to have a I shape groove form structure.

[0020] When the friction stir welding is carried out on the two frame members 30, in order not to make a gap between the two frame members 30 (or to make a gap having a predetermined size), the frame members 30 are restrained on a stand 60, with the raised portion 32 of the plate 31 directed upwardly and the plate 31 lying on the stand 60. Thus the welding portion at the edges of the extruded frame members 30 contacts and is supported by the stand 60. The stand 60 is made of steel.

[0021] A rotary tool 70 for carrying out the friction stir welding of the two frame members 30 is inserted into the welding portion from above. The rotary tool 70 has a large diameter portion 71 and a small diameter portion 72 as a tip end (lower end) of the large diameter portion 71.

[0022] A boundary 73 (an axially end portion of the large diameter portion 71) between the large diameter portion 71 and the small diameter portion 72 of the rotary tool 70 has a curved shape and is recessed towards the large diameter portion 71. The small diameter portion has a screw structure. During the friction stir welding, the boundary 73 is positioned in the raised portion 32 of the frame member 30. In other words, the boundary 73 is positioned at an intermediate level between the level of the top face 32c of the raised portion 32 and the level of the face 31b at the inner side of the plate 31 of the frame member 30 (i.e. the general inner face of the plate 31).

[0023] The friction stir welding is carried out by rotating the rotary tool 70 and inserting it into the welding portion of the two frame members 30 and further rotating and moving the rotary tool 70 along the welding line of the two frame members 30. The axis center line of the rotary tool 70 is positioned at the end faces 32b of the frame members 30.

[0024] Further, the axis of the rotary tool 70 at the large diameter portion 71 is inclined rearwardly with respect to the moving direction of the rotary tool 70. Accordingly, the front end of the large diameter portion 71 is positioned outwardly (in Fig. 4, above the top face 32c) from the top face 32c of the raised portion 32 of the frame member 30.

[0025] The rear end of the large diameter portion 71

of the rotary tool 70 in its movement direction is positioned in the raised portion 32 (e.g. at the level of a line 32d). In other words, the rear end of the large diameter portion 71 is positioned between the top face 32c of the raised portion 32 and an extension line of the face 31b of the plate 31 of the frame member 30. The above stated "front" and "rear" are defined with reference to the moving direction of the rotary tool 70.

[0026] The relationships between the sizes of the respective parts will be explained. The width W1 of the top faces 32c of the raised portions 32 of the frame members 30 when the two raised portions 32 are abutted is larger than the diameter d of the small diameter portion 72 of the rotary tool 70 but is smaller than the diameter D of the large diameter portion 71. The width W1 of the top faces 32c may be larger than the diameter D of the large diameter portion 71. The width W2 of the base portion of the two raised portions 32 is larger than the diameter of the large diameter portion 71. The top face 32c of the raised portion 32 and the face 31b of the plate 31 are connected by a sloping face 32e.

[0027] The height H of the small diameter portion 72 is such that, when the boundary 73 at the rear end of this portion 72 is positioned in the raised portions 32, the tip end of the small diameter portion 72 is close to the stand 60. For example, the distance between the outer face 31c of the plate 31 and the tip end of the small diameter portion 72 is 0.1 mm. In other words, the location of the tip end of the small diameter portion 72 is chosen to avoid its contact with the stand 60.

[0028] With the two extruded frame members 30 fixed to the stand 60, the friction stir welding is carried out. The apparatus for rotating the rotary tool 70 has rollers which move with the travel movement of the rotary tool 70. These rollers are arranged on both sides of and in front of and behind the rotary tool 70 in its movement direction, and, when the rotary tool 70 is inserted into the two frame members 30, contact the faces 31b of the two frame members 30 to press the two frame members 30 towards the stand 60.

[0029] Fig. 5 shows the state or condition of the two frame members 30 after the friction stir welding. The material of the raised portions 32 in which the large diameter portion 71 has been inserted is supplied to a gap between the abutted two extruded frame members 30 and is filled out to the outer face of the two frame members 30 as a facet. Some of the material remains as a pair of fins. Accordingly, a central portion of the two raised portions 32 forms a recessed portion 35. The gap between two frame members 30 is buried by the material which is softened by the rotation of the rotary tool 70. For example, the material of the raised portions 32 is moved into the gap and the gap is buried by this material of the raised portion 32.

[0030] By the tip end of the small diameter portion 72 of the rotary tool 70 softened material is moved into the lower portion of the gap, and then the gap is filled or buried by this softened material. As a result at the outer faces 31c of the frame members 30 the gap is filled substantially to the level of these outer faces 31c. A reference numeral 36 indicates a welding bead which is formed by this method.

[0031] Since the welding portion at the outer faces 31c is formed substantially to the level of the outer faces 31c, the thickness of the putty during the welding can be made thin. Further, since there is no raised portion of the bead 36 at the outer faces 31c, the outer face of the car body can be finished, e.g. by hair line processing, and needs no coating.

[0032] Pairs of the extruded frame members 40 are welded together in the same manner as the members 30. Next, an assembly of the welded extruded frame members 30 and an assembly of two extruded frame members 40 are mounted and fixed on the stand 60 as shown in Fig. 6 and Fig. 1. In advance, the ribs 43 are cut off at the vicinity of the abutted region which becomes the welding portion. This portion of the frame member 40 is made smooth, so that during the welding stir welding, the vicinity of the friction stir welding region is pressed by the rollers described above.

[0033] Next, as shown in Figs. 1 and 2, at the abutting portions (the welding portions) of the two assemblies, padding welding is carried out at the end portions of the two extruded frame members 40. It is desirable that the height and width of padding welding pads 42 correspond to the height and width of the raised portion 32 of the frame member 30. It is desirable to carry out this padding welding continuously along the friction stir welding line but it can be carried out intermittently. The pads 42 of the padding welding may be either formed wholly of welding material or be pads of material fixed in place by welding material.

[0034] For example, as indicated in Fig. 2 the padding welding is carried out for about 1 cm and is omitted for about 1 cm, repeatedly. This padding welding material has a strength such that during the friction stir welding the material does not fly out due to the rotation of the rotary tool 70. It is permissible that due to the large diameter portion 71 of the rotary tool 70 the material is piled up as fins so that the recessed portion 35 is formed.

[0035] Next, as described above with reference to Fig. 4, friction stir welding is carried out on the frame members 30 and the frame members 40. By the friction stir welding, a welding bead is formed substantially to the level of the outer faces 31c and 41c of the plates 31 and 41, similarly as is shown in Fig. 5.

[0036] If no padding welding portions 42 are made, since the large diameter portion 71 and the small large diameter portion 72 of the rotary tool 70 are not well inserted into abutment zone of the frame member 30 and the member 40, the material of the raised portion 32 flies out as the fins and the filling of the material into the gap is not well achieved. As a result good welding can be not carried out on the extruded frame members 30 and 40.

[0037] However, in this embodiment according to the

present invention, since the padding welding portions 42 serve the function of the raised portion 32 of the frame member 30, good welding of the frame members 30 and 40 can be carried out.

[0038] The padding welding portions 42 are formed intermittently in this embodiment, but during the friction stir welding material movement is carried out from the raised portion 32 of the frame member 30 to the side of the frame member 40.

[0039] Further, with the rotation and the movement of the rotary tool 70, the materials of the raised portion 32 and the padding welding portions 42 are moved towards the rear side of the rotary tool 70. In this way good welding where no padding welding portion 42 exists can be substantially achieved.

[0040] The welding portion in this case becomes substantially as shown in Fig. 5. The raised portion 32 of the extruded frame member 30 is the same as in Fig. 4, and the portions which correspond to the raised portion of the extruded frame member 40 is formed by the padding welding.

[0041] When the outer face of the body is finished without painting, the padding welding may be carried out by the TIG welding method. The filler material is the same material as that of the frame members 30 and 40. For example, by cutting the frame members 30 and 40, the filler material is provided. For example, the end materials of the frame members 30 and 40 are used for the filler material. With this method, since there is no change of colour at the welding portion, a good appearance can be obtained. When the filler material is another material, a change of colour appears at the welding portion and a good appearance cannot be obtained.

[0042] In this embodiment according to the present invention, before or after the padding welding the frame members may be installed on the stand 60.

[0043] In this embodiment of the present invention, extruded frame members are welded to each other for constituting the side structure body, but the invention can be applied to other members.

[0044] Another embodiment according to the present invention shown in Figs. 7 and 8 will now be explained. Extruded frame members 80 are arranged with their longitudinal direction in the longitudinal direction of a car body. Each extruded frame member 80 is a hollow shape frame member made of an aluminium alloy material. A raised portion is formed at both faces of the edges in the width direction of the extruded frame member 80.

[0045] The welding of the frame members 80 to each other is carried out by friction stir welding by utilizing the raised portions, as described above. Fig. 7 shows windows 86 and an entry and exit port 87.

[0046] Extruded frame members 90,95 constitute a frame of the entry and exit port 87. The frame members 90 are the vertical sides of the frame and the frame members 95 are the upper and lower sides of the frame.

[0047] The frame members 90,95 are welded to each other by a suitable welding method. The frame members 90,95 and the frame members 80 are welded together by the friction stir welding method. The frame member 90 is a hollow shape frame member made of an aluminum alloy material (see Fig. 8). Raised portions 92 are provided at both welding portions of the frame member 90. Further, projecting flanges or lips 93 which project towards the frame member 80 are provided. The projecting lips 93 are inserted adjacent the inner sides of the two plates 81,82 of the frame member 80. In the frame member 80, the inner cross rib 83 is cut off to allow insertion of the projecting lips 93. As Fig. 8 shows, the abutting faces of the raised portion 92 and the frame member 80 are located in a region which is a projection of the thickness of the cross-web 91 of the frame member 90.

[0048] The construction of the frame member 95 is the same to the construction of the frame member 90. The two plates 81 and 82 are substantially parallel.

[0049] After the frame members 80 have been joined by friction stir welding, the frame members 90 and 95 are arranged. The frame members 80, 80, 90 and 95 (excluding the raised portion 92) are mounted on the stand 60. Along the frame members 90 and 95, padding welding is carried out to end portions of the frame members 80 to provide pads 42 in a similar manner as shown in Fig. 2, alongside each raised portion 92. After that the friction stir welding is carried out.

[0050] The friction stir welding is carried out successively at each side or is carried out simultaneously to both sides. After the friction stir welding, residue of the raised portion and the padding welding portion at the car body outer side of the railway vehicle is cut off and then the car body outer side of the railway vehicle is made smooth.

[0051] The above stated embodiment according to the present invention can be applied to a case in which the frame of the window is installed according to the friction stir welding. Further, in the above stated embodiment the hollow shape frame member is adopted, but also the frame member shown in Fig. 1 can be used.

[0052] The present invention can be applied when members having a different thickness at their ends due to a manufacture error, are abutted. When the heights of the surfaces at the welding portion differ, padding welding is carried out on the lower member and then the friction stir welding can be carried out.

[0053] A further embodiment shown in Fig. 9 will now be explained. The structure shown in Fig. 9 corresponds considerably to that of Fig. 8. The rib 83 of the end portion of the hollow frame member 80 and the end portion of the plate 82 of the inner side of the car body are cut off and removed. An end portion of an outer side of car body of an extruded frame member 100 is abutted to the plate 81. At this end portion of the extruded frame member 100 a raised portion 102 is provided and this raised portion 102 projects towards the outer side of the car body.

[0054] The outer face of the extruded frame member 100, other than the raised portion 102 and the outer face of the plate 81 are at substantially the same level. A projection lip 103 of a face at the inner side of the car body of the extruded frame member 100 overlaps the plate 82 at the inner side of the car body of the extruded frame member 80. The extruded frame member 100 is not a hollow shape frame member, for strength reasons. This extruded frame member 100 is a solid frame member.

[0055] With the solid extruded frame member 100 is mounted on the stand 60, friction stir welding is carried out on the abutted portion between the plate 81 and the extruded frame member 100 from above. The friction stir welding manner is carried out in accordance with the invention using the raised portion 102 and padding welding. Next the above stated structure body is reversed and then the projection lip 103 and the plate 82 welded by fillet welding using the arc welding manner. If the projection lip 103 is absent, the abutted portion between the plate 82 and the extruded frame member 100 is joined by welding.

[0056] According to the present invention, in summary, where the height position of the surfaces of the two members at the welding portion of the two members differs, excellent welding of the two members can be obtained.

Claims

1. A friction stir welding method in which the height positions of adjacent surfaces of two members which are to be welded differ, characterized by carrying out padding welding to the lower of the two surfaces prior to performing the friction stir welding from the side of the two surfaces.

2. A friction stir welding method according to claim 1, wherein the padding welding is carried out at spaced locations along the direction of friction stir welding.

3. A friction stir welding method comprising the steps of:

   (i) abutting the end portions of a first member having an end portion of a first thickness and a second member whose end portion is thinner than said first thickness;

   (ii) carrying out padding welding to said end portion of said second member; and

   (iii) carrying out friction stir welding to said abutted end portions from the side at which said padding welding was performed.

4. A friction stir welding method according to claim 3 wherein both said members are extruded members, and in their welded position the extrusion direction of the first member is perpendicular to that of the second member.

5. A method of manufacturing a side structure of a car body comprising the steps of:

   (i) providing two sub-assemblies of extruded members by friction stir welding of a plurality of the extruded members in each case;
   (ii) abutting respective welding portions of the two sub-assemblies such that the respective extrusion directions of the extruded members of the two sub-assemblies are substantially orthogonal, a first one of the sub-assemblies having a raised portion along its said welding portion at a side edge of one said extruded member;
   (iii) before or after abutting the sub-assemblies, carrying out padding welding to the welding portion of the second sub-assembly; and
   (iv) carrying out friction stir welding to join the sub-assemblies from the side at which said padding welding was performed.

6. A manufacturing method according to claim 5, wherein said padding welding is carried out by TIG welding using as a filler material the same material as the material of at least one of the sub-assemblies at the welding portion thereof.

7. A method of manufacturing a side structure of a car body comprising the steps of:

   (i) carrying out friction stir welding to join a plurality of extruded members to form a sub-assembly;
   (ii) abutting edge portions of respectively said sub-assembly and a frame structure, which is a frame of an entry/exit port or a frame of a window, the edge portion of said frame structure having a raised portion along said edge portion thereof;
   (iii) before or after step (ii), carrying out padding welding to said sub-assembly along said edge portion thereof; and
   (iv) carrying out friction stir welding to join the sub-assembly and the frame structure from the side at which said padding welding was performed.

8. A manufacturing method according to claim 6, wherein said raised portion is on the inner side of the car body and said padding welding and said friction stir welding of at least one of steps (i) and (iv) are carried out from the inner side of said car body.

9. A structure in which:

an end portion of a first member and an end portion of a second member abutted together are joined by welding;
at the welding line, a welding portion protrudes in the thickness direction of the members and a central portion in the width direction of said welding portion is recessed; and
said protruding welding portion comprises material of said first member and padding welding material on said second member.

10. A structure according to claim 9, where

said first member and said second member are extruded frame members; and
said end portion of said second member is an end portion in the extrusion direction of the second member.

11. A car body in which:

an end portion of a first extruded member and an end portion of a second extruded member are joined by welding, the extrusion directions of the first and second extruded members being substantially orthogonal;
at the welding line, a welding portion protrudes in the thickness direction of the members and a central portion in the width direction of said welding portion is recessed; and
said protruding welding portion comprises material of said first member and padding welding material on said second member; and
said protruding welding portion is at the inner side of the car body.

12. A car body according to claim 11, wherein

each of said first and second extruded members comprises a plurality of extruded bodies welded together with their extrusion directions aligned; and
said first and second extruded members are in a side structure of said car body.

13. A car body according to claim 11, wherein
said second member is a frame of an entry/exit port or a frame of a window.

14. A friction stir welding method comprising the steps of:

(i) partially removing a cross rib extending between opposed plates at an end portion in the extrusion direction of an extruded hollow frame member;
(ii) abutting an extruded frame member to said end portion of said extruded hollow frame member with the respective extrusion directions of said extruded hollow frame member and said extruded frame member orthogonal and said extruded frame member inserted between said opposed plates;
(iii) making the thickness of said extruded hollow frame member and the thickness of said extruded frame member substantially the same at the welding location; and
(iv) carrying out friction stir welding at the abutted portion from outside said extruded frame member.

15. A friction stir welding method according to claim 14, wherein

an end portion of said abutted portion of said extruded frame member has a raised portion which projects outwardly from the thickness of said extruded frame member, and
the friction stir welding is carried out on said abutted portion including said raised portion from outside said extruded frame member.

16. A friction stir welding method comprising the steps of:

(i) partially removing a cross rib extending between opposed plates at an end portion in the extrusion direction of an extruded hollow frame member and an end portion of a first one of said plates;
(ii) abutting a second extruded frame member to said end portion of said first extruded frame member by

(ii.a) overlapping or abutting an end portion of the second plate of said first frame member to said second frame member; and
(ii.b) overlapping and abutting said first plate to said second frame member;
(ii.c) with the extrusion directions of said first and second frame members being substantially orthogonal;

(iii) making to substantially the same level an outer face of second plate of said first frame member and an outer face of said second frame member; and
(iv) carrying out friction stir welding of said abutted portion between said second plate of said first frame member and said second frame member from outside said first frame member.

17. A friction stir welding method according to claim 16, wherein

an end portion of said abutted portion of said second plate of said first frame member has a raised portion which projects to the outside, and said friction stir welding is carried out on said abutted portion including said raised portion.

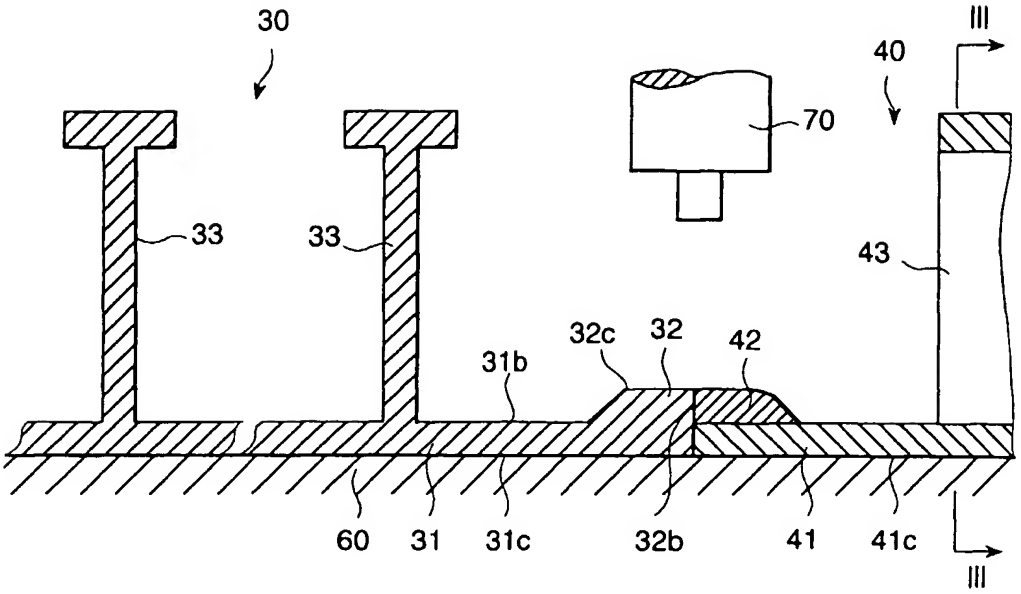
18. A structure, wherein

a first extruded frame member and a second extruded frame member are welded from outside said first frame member by friction stir welding,
a rib provided between two side plates of said first frame member is removed at least partially at a portion where said friction stir welding is carried out,
an end portion of said extruded frame member is inserted between said two plates, and
the extrusion directions of said frame members are arranged substantially orthogonally.

19. A structure, wherein

a plate of one side of a first extruded frame member and a second extruded frame member are welded from an outside said first frame member by friction stir welding,
a rib provided between first and second side plates of said first frame member is removed at a region where the friction stir welding is carried out and an end portion of said second plate at said welding region is also removed,
said second frame member is welded to said second plate, and
the extrusion directions of said frame members are arranged substantially orthogonally.

FIG. 1


30
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42
31b
60
31
31c
32b
41
41c
III

FIG. 2

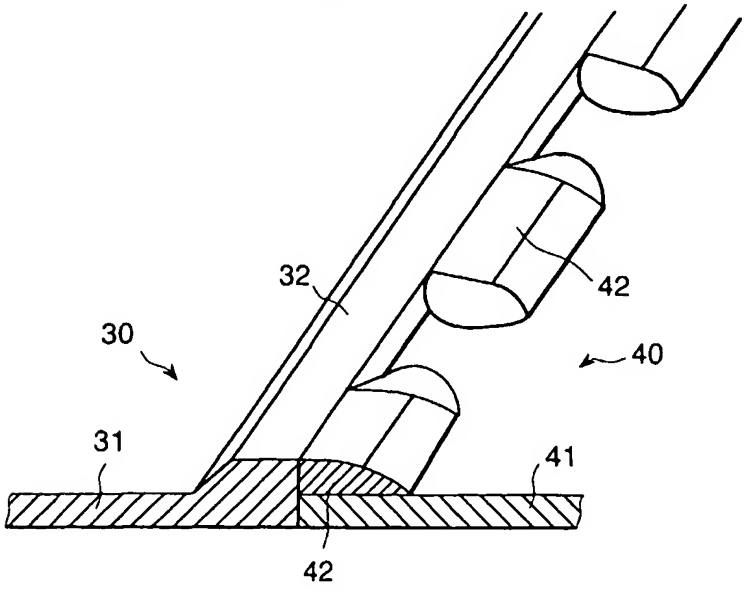
32
42
30
40
31
41
42

FIG. 3

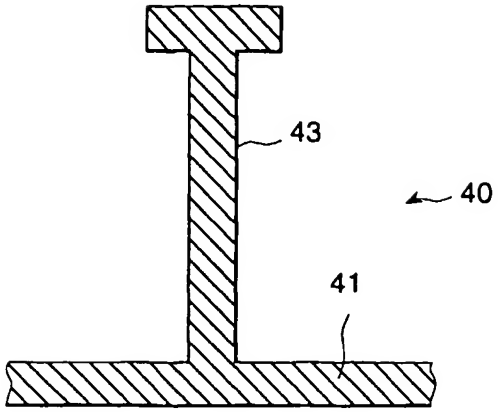
43
40
41

FIG. 4

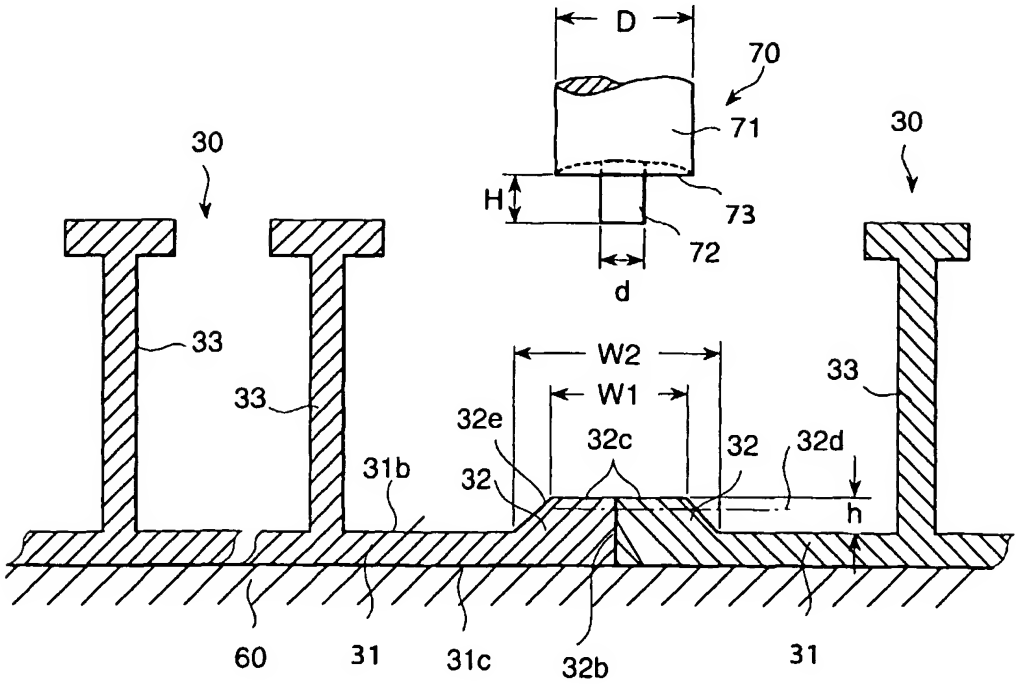
D
70
71
30
30
H
73
72
d
33
33
W2
W1
33
32e
32c
32
32d
31b
32
h
60
31
31c
32b
31

FIG. 5

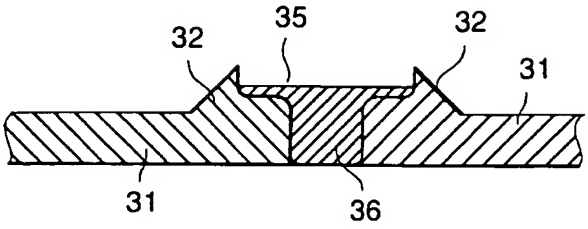

FIG. 6

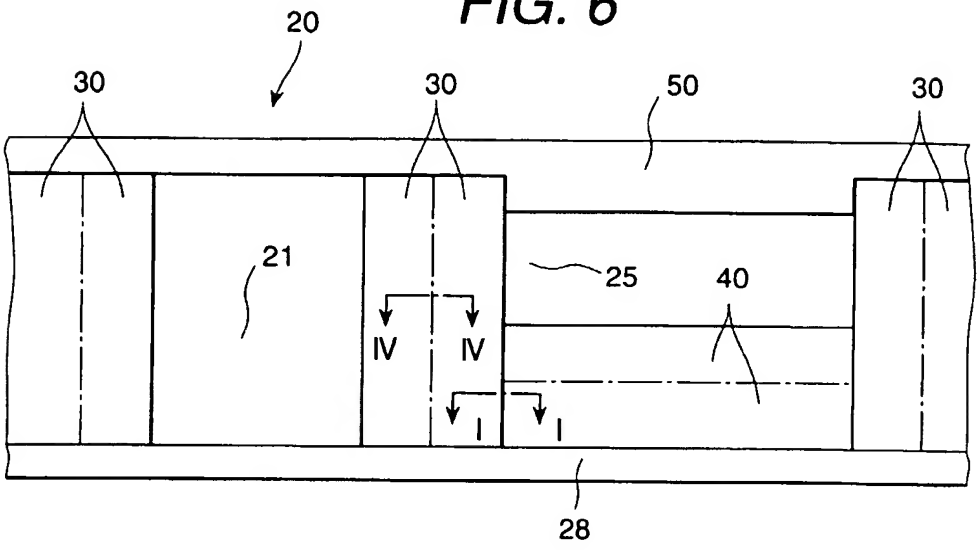

FIG. 7

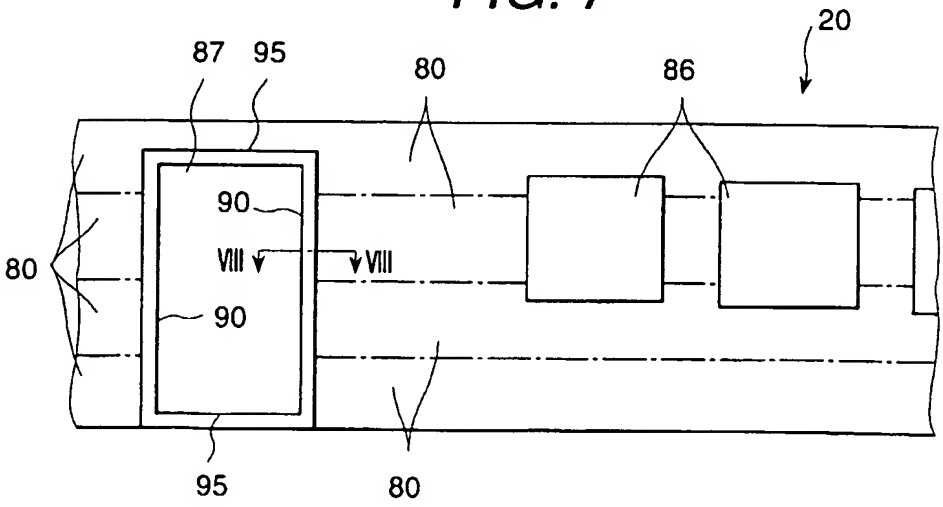

FIG. 8

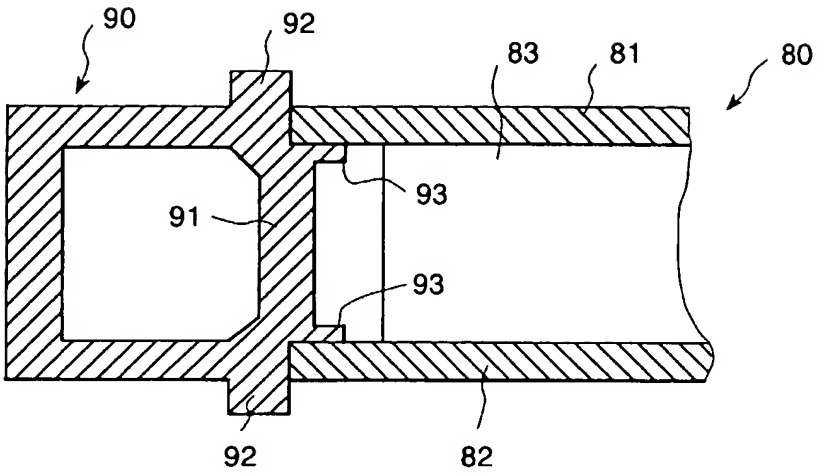

FIG. 9